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Performance deterioration of a communication link at 13 GHz due to rain

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Abstract : Performance deterioration of a microwave communication link situated between Panihati and Cossipore located in Indian eastern sector and operating at 13.059 GHz during monsoon months, July-August 2002, has been tested. The link suffers substantial attenuation due to rain. The communication link belonging to an operational agency was monitored and rain rate measurements were carried out on twenty four-hour basis by a fast response rain gauge. It was seen that the radio signal is characterized with a steady signal level of –42 to 44 dBm with fade of 1 to 2 dB under non-precipitation situation. It has been seen that audio service of the link is affected when the signal level was ≤ –69 dBm. The link does not serve the purpose at all when the signal level is ≤ –75 dBm. The cumulative distribution function (CDF) of the signal levels, attenuation values and rain rates have been derived. The results are discussed to indicate the performance of the communication link. Some techniques to provide extra gain in the radio system have also been suggested.

Keywords : Microwave, communication link, performance deterioration, audio service, rain rate and rain attenuation.

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1. Introduction

The demand of the requirement of more channels in radio communication systems has been growing in recent years. Since there is congestion in UHF and lower region of microwave bands, it has become necessary to go for higher and higher frequency above 10 GHz [1,2]. Radio waves in microwave and millimeter wave frequency band are subjected to several phenomena such as absorption, scattering, depolarisation *etc*, during their propagation through rain [3–7]. There is still paucity of the measured results on rain attenuation of radio wave in the tropical regions, in India. Recently, systematic simultaneous monitoring of communication links (having different path length) belonging to different operational agencies at 13 GHz and 18 GHz and measurements of rain rate were undertaken in Indian eastern sector and some useful results on attenuation were derived [8,9]. The monitoring work of the link operating at 18 GHz between Sonarpur and Jadavpur having path length ~8 km was carried out during July-August 2000 [9]. Another link operating at 13 GHz between Belur Moth and Tirriti Bazar of path length ~6.5 km was monitored during July-August 2001 [8]. The third link also operating at 13 GHz but having different path length between Panihati and Cossipore was monitored during July-August 2002.

A fast response rain gauge having integration time of 10 sec was also put on operation to measure the rain intensity on continuos basis. It has been seen that the signal level is characterized with a steady signal with a level of –42 to –44 dBm with a fade from 1 to 2 dB under clear air conditions. The communication link used to exhibit substantial loss of signal during rainy condition. The analysis of the experimental results on signal levels and rain rates has yielded the percentage of time for which the communication link does not serve the purpose under rainy conditions during monsoon months, July and August, over the Kolkata region.

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2. Source of data

A strip chart recorder recorded the signal level of the radio communication link between Panihati and Cossipore. The carrier intensity measurements were made on twenty-four hour basis during July-August 2002. The transmitter is situated at Panihati while the receiver is situated at a distance of 8.31 km at Cossipore. The transmitter power is 30 dBm and the receiver threshold is –84 dBm. The signal has vertical polarization.

The rain measurements in terms of rain intensity in mm/hr were carried out at a place, very near to the receiving end of the radio system over Kolkata during July-August 2002 by a fast response rain gauge having integration time ~10 seconds. The probability distribution of the rain rate has been derived from the rain rate measurements of all the rain events taken place during July-August 2002. It would have been more useful if we could have installed few more rain gauges along the path of the radio system. But it is very difficult to do so because lots of infrastructure facilities is required for such purpose. Moreover, the long-term probability distribution of rain rate has been established. If long term probability distributions of rain rate are estimated from rain rate measurements over different locations in a region, we find that there is not much variation (with in 5%) in probability distribution of rain rate from one location to another location. But, if case (rain event) by case (rain event) over different locations is taken then there exist some differences. The rain gauge is a microprocessor-based system [8,9]. It measures rain rate automatically. The program controls the sampling, storing and printing of the data of rain rate. The rain water is collected in a collector and converted into approximately equal size drops. The number of drops for 10 sec time period is counted electronically. The counts are then converted into rainfall rate and given in mm/hr [8,9].

3. Results and discussion

The fast response rain gauge has been used to obtain rainfall rate and correlate them with variations in signal attenuation. There were several rain events occurred during the course of rain measurements over Kolkata during July-August 2002. Different rain event was characterized with different variation of rain rate. The minimum rain rate was recorded with fast response was ~3 mm/hr while the maximum rain rate was around ~160 mm/hr. The cumulative distribution of rain rate, which has been obtained from several rain events occurring during July-August 2002, is presented in Figure 1. It is seen that the rain rate ~20 mm/hr exceeds for 50% of the time and rain rate ~58 mm/hr exceeds for 5% of time. The maximum rain rate obtained was ~160 mm/hr during this period.

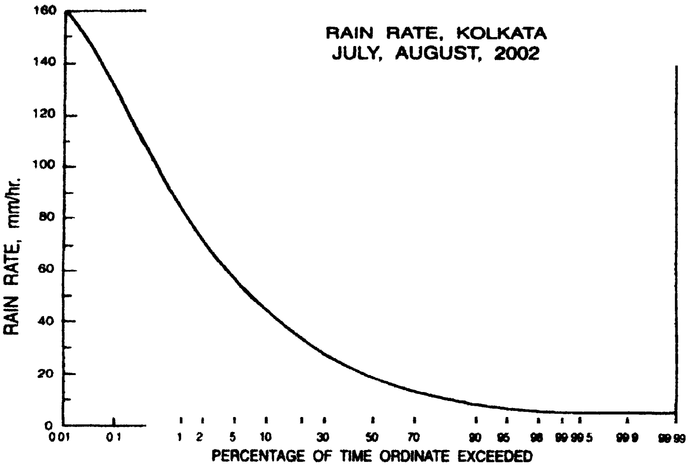

Figure 1. Probability distribution of rain rate during July-August 2002 over Kolkata.

The radio signal variation measured during different rainy conditions in July-August 2002 over Panihati-Cassipore communication link is presented in Figures 2–5.

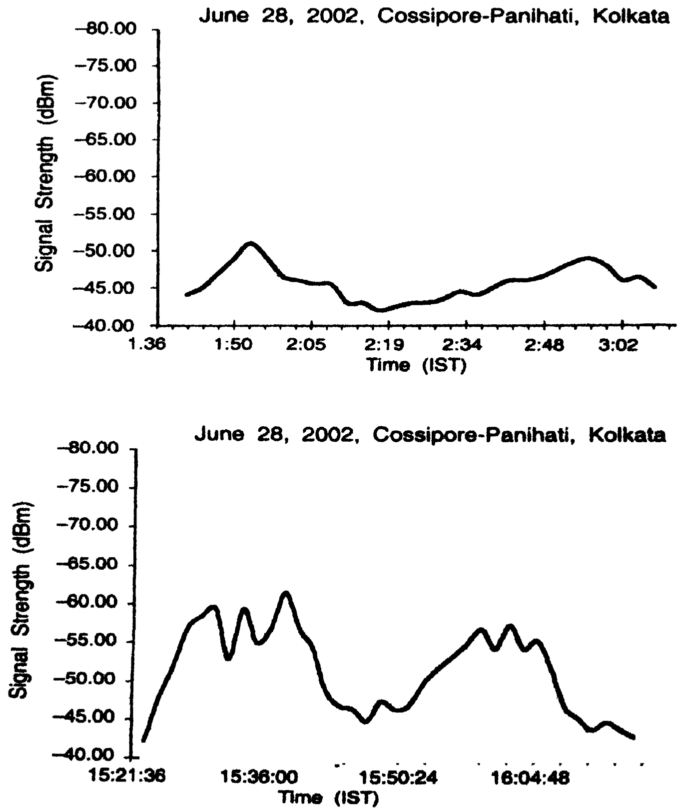

Figure 2. Typical signal level variation over Panihati-Cossipore link under varied rainy conditions.

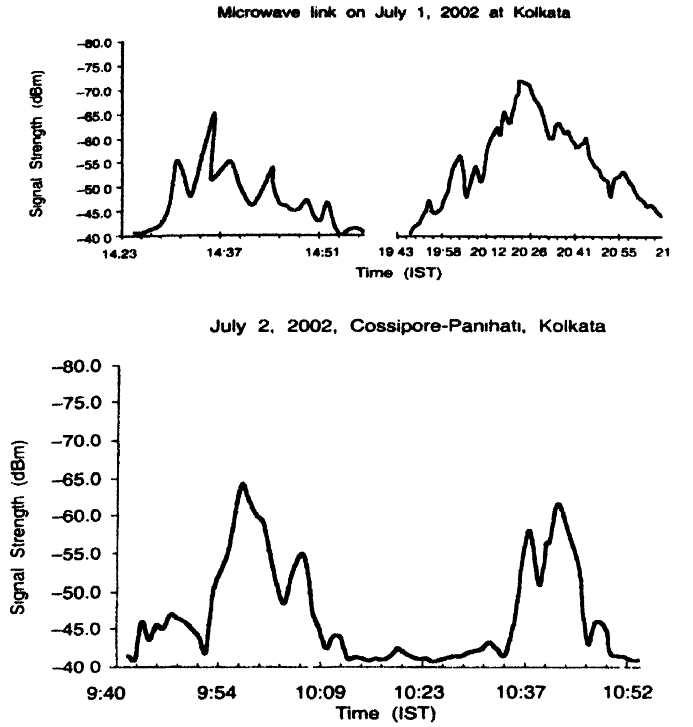

Figure 3. Typical signal level variation over Panihati-Cossipore link under varied rainy conditions.

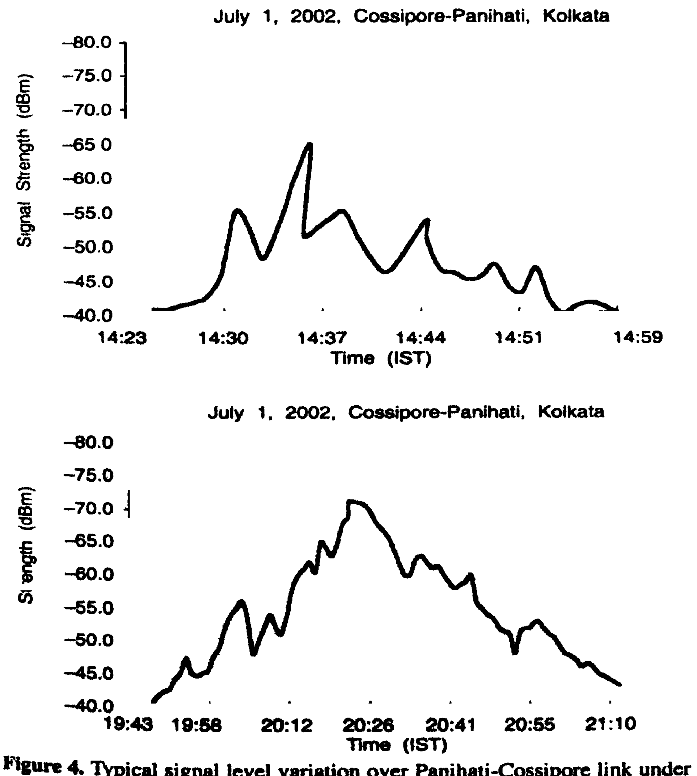

Figure 4. Typical signal level variation over Panihati-Cossipore link under varied rainy conditions.

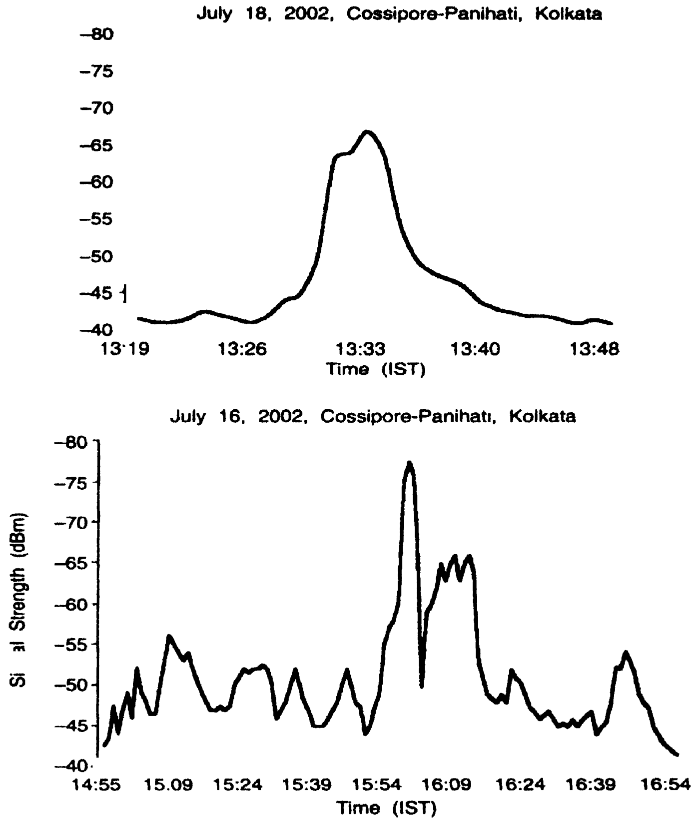

Figure 5. Typical signal level variation over Panihati-Cossipore link under varied rainy conditions.

It is seen that the radio signal exhibits slow and rapid amplitude variations. It is observed that the maximum attenuation varies from 8 dB to 35 dB. The cumulative distribution of the signal level has also been obtained for the rain events. It is seen from all such measurements that the signal level varies from –42 dBm to –82 dBm. The probability distribution of signal level is presented in Figure 6. The signal level around –47 dBm exceeds for

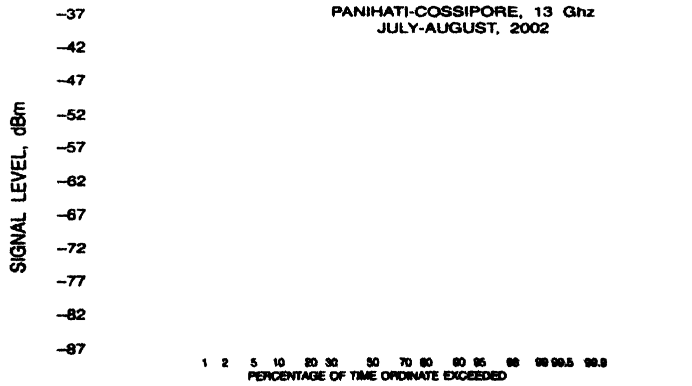

Figure 6. Probability distribution of signal level deduced from amplitude variation measurements.

50% of the time in July-August 2002. The performance of the link in relation to audio service starts deteriorating when the signal level is around ≤ –69 dBm. It has been reported that the link does not serve the purpose al all when the signal level ≤ –74 dBm. It has been seen that the signal level –69 dBm exceeds for around 95% of the time during July-August 2002. It is estimated that for 5% of the time during July-August 2002, the link had deteriorated performance. The signal level –69 dBm was found to be associated with a rain rate around ~58 mm/hr. The cumulative distribution of attenuation during July-August 2002 is presented in Figure 7. The attenuation

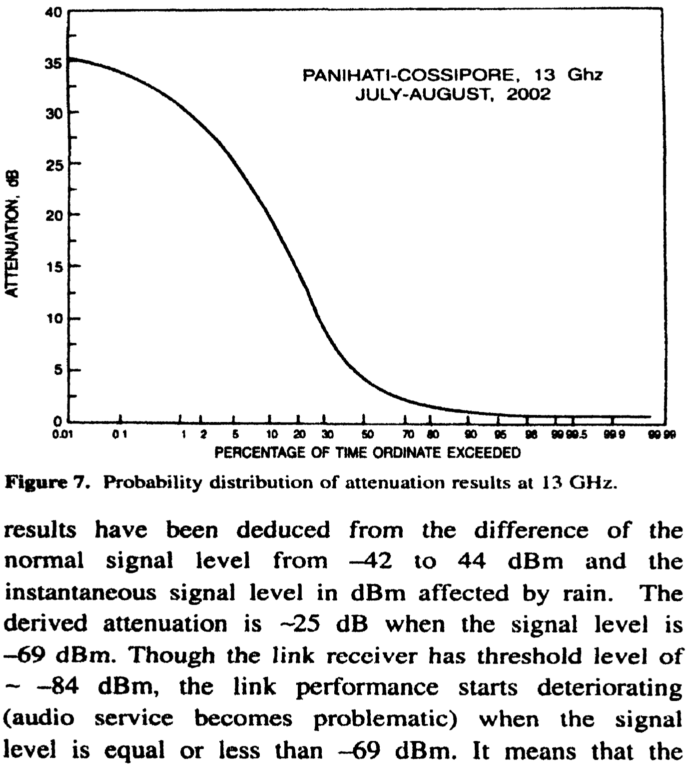

Figure 7. Probability distribution of attenuation results at 13 GHz.

results have been deduced from the difference of the normal signal level from –42 to 44 dBm and the instantaneous signal level in dBm affected by rain. The derived attenuation is ~25 dB when the signal level is –69 dBm. Though the link receiver has threshold level of ~ –84 dBm, the link performance starts deteriorating (audio service becomes problematic) when the signal level is equal or less than –69 dBm. It means that the threshold of –84 dBm is right kind of threshold of the system to work properly under clear air conditions. During rain, –69 dBm should be taken as the threshold level for the radio system. It indicates that if the attenuation is greater than 25 dB, the link performance becomes unsatisfactory. It is seen in Figure 7 that the attenuation exceeds 25 dB for 5% of the time in July-August 2002. This indicates that the communication link did not serve the purpose for 5% of time in July-August 2002. It is revealed from the rain rate distribution (Figure 1) that the attenuation level ≥ 25 dB correspond to a rain rate ≥ 58 mm/hr. The attenuation level around ~30 dB is found to occur for 1% of time while the rain rate is ≥ 90 mm/hr is found to exceed for 1% of time during July-August 2002.

It has been seen that the performance of the communication link between Panihati-Cossipore does not serve the purpose for 5% of the time during July-August 2002, due to rain. In order to get 99.99% service of the communication link, extra gain around 12 to 15 dB is to be provided to the radio system. In order to have an extra gain of such order, the radio system is to be fitted with low noise amplifier (LNA). The extra gain at the antenna is achieved by deploying a LNA with the antenna. In the microwave communication engineering, it is an established practice to deploy low noise amplifier of different sensitivity to boost of the weak signal. These are not a part of initial design consideration. These are deployed after the review of the performance for significant period of time and constitute one of the remedial measures. User organizations in Indian telecom sector in southern and northern India have deployed LNA's in various paths. The other option is by increasing the power of transmitter of the radio system. But the increase of power is not cost effective and there is engineering problem as well, once the design aspect of the link is completed.

4. Conclusion

The Panihati-Cossipore communication link operating at 13 GHz did not serve the purpose for 5% of time during July-August 2002 due to rain. It has been observed that when the rain rate is equal or more than ~58 mm/hr, the signal level is equal or less than –69 dBm and communication link suffers attenuation ≥ 25 dB. The communication link can provide satisfactory service for 99.99% of the time during monsoon period which is considered to be worst the months in Kolkata if an extra gain around 12 to 15 dB is provided in the radio system. Such extra gain is possible by deploying a suitable LNA with the antenna.

These results can be utilized for further establishment of the links affected by rain over this part of our country.

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